



The Future of Navigation

For several years now, the Global Positioning System (GPS) has been recognized as the future of navigation for many peaceful applications, including those for various modes of transportation. The civil aviation community has been one of the main benefactors of GPS due to its flexibility and worldwide applicability. As a direct result of these benefits to the civil community, U.S. Vice President Al Gore announced a GPS modernization effort in January 1999 to extend the capabilities of GPS even further than those currently enabled by the existing GPS constellation.

GPS Modernization

One of the main components of this modernization effort is two new navigation signals that will be available for civil use. These signals will be in addition to the existing civilian service broadcast at 1575.42 MHz (L_1). The first of these new signals will be a Coarse/Acquisition (C/A) code located at 1227.60 MHz (L_2), and will be available for general use in non-safety critical applications. This will be available beginning with the initial GPS Block IIF satellite scheduled for launch in 2003.

The other signal, located at 1176.45 MHz (L_5), will be available on GPS Block IIF satellites scheduled for launch beginning in 2005. This new L_5 signal falls in a band which is protected worldwide for aeronautical radionavigation, and therefore will be protected for safety-of-life applications. Additionally, it will not cause any interference to existing systems. Therefore, with no modification of existing systems, the addition of L_5 will make GPS a more robust radionavigation service for many aviation applications, as well as all ground-based users (maritime, railways, surface, shipping, etc.).

At the current GPS satellite replenishment rate, all three civil signals (L_1 -C/A, L_2 -C/A, and L_5) will be available for initial operational capability by 2010, and for full operational capability by approximately 2013.

Benefits of L_5

L_5 will provide significant benefits above and beyond the capabilities of the current GPS constellation, even after the planned second civil frequency (L_2) becomes available. Benefits include precision approach navigation worldwide, increased avail-

ability of precision navigation operations in certain areas of the world, and interference mitigation.

Precision Navigation Operations Worldwide

GPS offers the capability to provide a safe and efficient seamless satellite-based global navigation system that will be responsive to the future needs of civil aviation. The addition of L_5 should significantly increase this ability in providing aviation and other transportation applications with continuous, highly accurate, three-dimensional position information.

The availability of L_5 offers the potential of providing precision approach capability throughout the footprint of a satellite-based augmentation system (SBAS) geostationary (GEO) satellite. Even outside the defined SBAS service areas, users in the footprint of these broadcasts, which is essentially most of the world, will be able to use dual frequency avionics (L_1 and L_5) to provide a precision approach capability with little or no ground infrastructure investment. These dual frequency avionics will use integrity data from augmentation system corrections that are broadcast from these GEOs on L_1 or L_5 .

In the event of interference on either L_1 or L_5 , these regions within the footprints, can revert to non-precision approaches using GPS with integrity data from SBAS corrections broadcast on L_1 or L_5 or GPS with receiver autonomous integrity monitoring (RAIM).

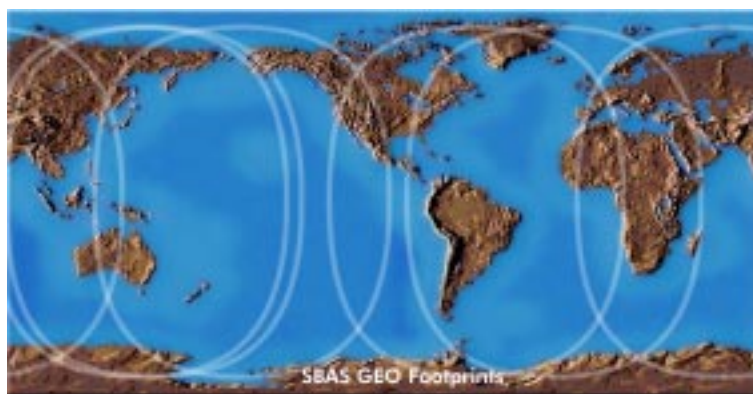


Figure 1: Regions within the GEO footprints represent the area of the world that will gain precision approach capability with the addition of L_5 . The GEO footprints shown here represent those of the U.S. Wide Area Augmentation System (WAAS), the European Geostationary Navigation Overlay Service (EGNOS), and the Japanese MTSAT Satellite-Based Augmentation System (MSAS).

Increased Availability of Precision Navigation Operations

The GPS modernization effort is compatible and complements that of the U.S. WAAS. The L₅ signal will be available on additional WAAS GEOs scheduled for launch in 2004/2005. When both L₁ and L₅ are available, avionics will use a combination of signals to provide the most accurate service possible, thereby increasing availability of the service. These avionics will use ionospheric corrections broadcast by WAAS, or self-generated onboard dual frequency corrections, depending on which one is more accurate.



Figure 2: The shaded areas represent conceptual SBAS service areas where L₅ will improve the availability of precision approach operations.

Interference Mitigation

Due to the low power of GPS signals, interference has been identified as a challenge related to the use of GPS. Despite this, the technical feasibility of using augmented GPS as the only means of navigation in the aircraft as well as the only navigation service provided by the Federal Aviation Administration (FAA) was confirmed as technically feasible in an independent study conducted by Johns Hopkins University Applied Physics Laboratory. However, the study did recommend efforts to mitigate the effects of intentional interference, unintentional interference, and atmospheric disturbances on GPS and its augmentation systems. The mitigation of interference is not only important to aviation, but to other GPS applications as well. To mitigate the effects of interference and any impact on civil aviation safety-of-life operations, the FAA is planning to use the new navigation signal at L₅ (1176.45 MHz) for both WAAS and the Local Area Augmentation System (LAAS).

The availability of L₅ will encourage the development of avionics that can use GPS signals on both L₁ and L₅ to eliminate ionospheric errors. For example, WAAS will broadcast ionospheric corrections and integrity data on both L₁ and L₅. In the event of interference on either L₁ or L₅, avionics will be capable of conducting precision approaches, as currently designed by the FAA, using the GPS and the WAAS ionospheric corrections and integrity data broadcast on whichever frequency is available (either L₁ or L₅).

Similarly, LAAS will broadcast corrections and integrity data pertinent to both L₁ and L₅. In the event of interference on either L₁ or L₅, the avionics will be able to conduct precision approaches using the data broadcast for the frequency available.

The addition of L₅ will have a profound impact on both the new and existing applications of GPS for navigation.

Commonly-Asked Questions/Misconceptions:

Q. I've heard that L₅ cannot be used where there is Distance Measuring Equipment (DME). Is this true?

A. DMEs will not affect the use of L₅ for ground-based applications (such as surveying, intelligent transportation systems, and positive train control). It will also not affect civil aviation use of L₅ at low altitudes (i.e., precision and non-precision approaches). DMEs will only affect the L₅ signal at very high altitudes (enroute flights) in the areas where there is a very high density of DMEs operating in the L₅ band (1166–1186 MHz). A nation or region's level of confidence in satellite-based navigation systems will determine its policy to reassign frequencies for some of these DMEs.

Q. How much will L₅ cost to the user community?

A. L₅ will be free to the user as part of the basic GPS service. Therefore, it will provide immense benefit by enabling precision approaches anywhere in the world with no equipment other than the appropriate avionics and minimal to no ground infrastructure investment.

Q. When can a nation or region start using GPS to increase aviation capability, efficiency, and safety?

A. Now. GPS is available free of charge worldwide. It is very accurate even without new modernization efforts and augmentations. The service will only get better with L₅ and other planned enhancements.

For further information regarding the projected use of L₅ for civil aviation, please contact:

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